E: MOTIONS IN BARRED SPIRALS. VII. THE VELOCITY FIELD OF NGC 925*

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ABSTRACT

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Spectroscopic observations have been made of the nucleus and nine outer emission knots in NGC 925. The recession velocity of the galaxy is +710 km/sec. Across the central bar there is no variation in line-of-sight velocity. The outer knots have velocities within ±50 km/sec of the central velue. Several possible explanations for the absence of any appreciable gradients in the velocity field are described and the tentative conclusion is drawn that this is a galaxy with very small intrinsic angular momentum.

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NGC 925 is a spiral galaxy of low surface brightness; it has been classified Sc/SBc by Sandage (1961), Sd by Shapley (1943), and Sc$^+$ by Holmberg (1958). A direct plate taken at the prime focus of the 82-inch telescope is reproduced in Figure 1. Since one of the aims of our program of investigation of the dynamics and rotation of spiral galaxies has been to cover as wide a range of types as possible, this galaxy was placed on the observing list because of its classification intermediate between SBc and Sc. As can be seen from the plate, the galaxy is different in appearance from other barred spirals which we have investigated (Papers I - VI in this series) because of its large extent, lack of central condensation, and diffuseness.

Seven spectra have been obtained with the B spectrograph attached at the prime focus of the 82-inch telescope at McDonald Observatory, and a record of the observations is given in Table 1. Only spectra B 805 and B 1187 were centered on the nucleus. The arms of the galaxy contain many bright emission regions and the remaining five spectra were obtained by placing the slit in various orientations to pass through some of these. Figure 2 is a sketch of NGC 925 showing the orientation of the slit across the nucleus and the positions of the nine knots for which velocities were obtained.

The spectra were measured with a new Mann two-coordinate measuring machine at UCSD which has automatic read out on an IBM typewriter which, at the same time, is connected to an IBM keypunch which punches data cards automatically. The reductions were then carried out, as previously, on the CDC 1604 computer at UCSD. Velocities measured in this way as a function of distance along the slit are given in Table 2. All velocities are reduced to the sun and corrected for the basic solar motion (Vyssotsky and Janssen 1951); no correction for galactic rotation has been included. As can be seen from the tables, both Hα and [N II] λ6583 could be measured in the bar but only Hα could be measured in the emission knots.

The orientation of NGC 925 is not certain. The axis of the bright short bar lies in a position angle of about 113°. If this bar is not real but appears as a bar because of projection effects, then the line of nodes of the galaxy should be in position angle 113°. In Figure 3 we show a plot of the velocities as a function of distance from the center for spectrum B 805 in P.A. 113°. The curve is extremely flat over most of the galaxy; only the distant south-east emission knots have recession velocities which differ significantly from the central velocity. From the run of velocities across the bar a mean recession velocity of +580 km/sec has been adopted. A central velocity can also be obtained from spectrum B 1187 through the nucleus in P.A. 93°. However, velocities from this spectrum are all systematically high by about 60 km/sec with respect to the measured velocities in P.A. 113°. The effect is unexplained and, because of the good agreement between the other spectra, we assume that there is a systematic error amounting to about 0.004 mm in this spectrum. Although we list these measures in Table 2, we have not made use of them in deriving the mean velocity given above.

Our mean velocity of +580 km/sec is to be compared with the value of +587 ±98 km/sec (Mayall) and +420 ±200 km/sec (Humason) given by Humason, Mayall and Sandage (1956). If we correct our value for galactic rotation, putting v = 250 km/sec in the direction $\ell^{II} = 90°$, the true recession velocity becomes +710 km/sec. This value is so small that a distance determination based on it would be quite unreliable. However, Sandage (1961) has obtained a distance of 6.8×10^6 pc for the group of galaxies of which NGC 925 is a member (others are NGC 1023, 891, 1058, 1003 and IC 239). This distance was obtained by measuring the apparent sizes of H II regions in some of these galaxies. At this distance 1" ≅ 34 pc, so that the short bar in NGC 925 has a length of about 1400 pc and bright H II regions are visible in the arms at distances of 10 Kpc from the center.

For each of the emission knots a mean velocity with respect to the center has been obtained, and these values are listed in Table 3. For knot E the value is uncertain because Hα is weak. It can be seen that for all of the other knots the velocities are within about 50 km/sec of the central velocity.

When the mean recession velocity is subtracted from each of the measures in P.A. 113° it is seen that there is no line-of-sight motion in the bar of NGC 925 with respect to the center. Hence any motions in the bar must be at right angles to the line of sight, i.e., in the plane of the sky. For the outer regions of the galaxy, both in position angle 113° and in the emission knots, there is an indication of systematic velocities of approach on the southeast side of the galaxy, and of velocities of recession on the northwest side. These small velocites are probably the projections in the line of sight of rotational velocities in the plane of the galaxy, but it is not possible to deduce a meaningful rotation curve or a mass estimate for the galaxy.

We may sum up this investigation as follows. Our measures of the velocity field in the line of sight show that the differences are so small that very little can be deduced about the dynamics of the galaxy. Several factors may be contributing to this state of affairs:

(1) It is possible that this galaxy has very little angular momentum.

(2) The galaxy may have its principal plane of rotation very nearly at 90° to the line of sight.

(3) The orientation of the galaxy in space is uncertain and we may be observing several velocity components due to circulation in the bar, rotation of the system as a whole, and perhaps radial motions, which may be cancelling each other.

We have now made measurements of the velocity fields in some thirty spiral and barred spiral galaxies and this is the first example which has shown such

small velocity differences. In all of the barred spirals we have studied so far, NGC 7479, 3504, 1097, 1365, 5383, 613, very considerable velocity gradients have been present. NGC 925 is different in appearance from all of these because ot its large extent, lack of central concentration, and diffuseness. However, its apparent axial ratio is about 2:1 so it is hard to believe that it is orientated with its principal plane of rotation very nearly at 90° to the line of sight. Consequently, we tend to believe that this is a type of galaxy which has intrinsically very little rotation. However, our previous studies of barred spirals have led us to the conclusion that many types of motion are possibly present (cf. Burbidge, Burbidge, Rubin, and Prendergast 1964) so that we cannot rule out the wealth of possibilities concealed in (3).

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TABLE 1

OBSERVATIONS OF NGC 925

Spectrum No.	Date	Position Angle	Exposure (minutes)
B 805	Nov. 3, 1961	113° through nucleus	180
832	Nov. 18, 1961	57° through knots H, J	181
836	Nov. 20, 1961	88°.1 through knots E, F	120
864	Nov. 25, 1961	31° through knot A	154
865	Nov. 25, 1961	65° through knot G	148
1186	Jan. 8, 1964	122° through knots B, C, D	180
1187	Jan. 10, 1964	93° through nucleus	120

TABLE 2

VELOCITIES IN NGC 925 (REDUCED TO LOCAL STANDARD OF REST)
AS A FUNCTION OF DISTANCE FROM CENTER *

Distance From Center (Sec. of Arc)	Velocity (km/sec)
B 805	P.A. 113°
Hα	
N.W. -52.6	+594
-49.7	588
-46.8	605
-43.9	591
-41.0	584
-38.1	586
-34.5	572
-30.8	611
-27.2	619
-23.6	604
-20.0	589
-17.1	597
-14.2	597
-11.3	604
- 8.4	581
- 5.5	573
- 2.6	565
+ 0.3	579
+ 3.2	563
+ 6.1	585
+ 9.0	584
+11.9	606
+14.8	582
+17.7	596
+20.6	610
+23.5	623
+40.5	536
+43.4	526
+46.3	569
+49.2	567
+52.1	587
+74.6	534
+77.5	569
+80.4	558
+91.8	499
+103.4	500
+106.3	519
S.E. +109.2	523
[N II] 6583:	
N.W. -50.4	578
-47.5	595
-44.6	604
- 7.5	610
- 4.6	580
- 1.7	556
+ 1.2	594
+4.1	+570
+6.9	546
+9.8	568
+12.7	597
+15.6	596
+18.5	564
S.E. 21.4	563

Distance Along Spectrum (Sec. of Arc)	Velocity (km/sec)
B 832	P.A. 57°
Hα: Knot H	
S.W. 0	587
2.9	542
5.8	558
8.7	506
11.6	521
Knot J	
43.6	609
46.5	578
49.4	569
52.3	583
55.2	619
58.1	633
N.E. 61.0	616
B 836	P.A. 88°.1
Hα: Knot E	
S.W. 0	689:
2.9	654:
5.7	734:
8.6	684:
12.3	757:
Knot F	
30.2	586
33.1	588
36.0	637
38.9	647
N.E. 41.8	680
B 864	P.A. 31°
Hα: Knot A	
S.W. 0	617
2.9	615
5.8	619
N.E. 8.7	632

Distance Along Spectrum (Sec. of Arc)	Velocity (km/sec)
B 865	P.A. 65°
Hα: Knot G	
S.W. 0	+572
2.9	573
5.8	573
8.7	519
11.6	527
14.5	519
17.4	495
N.E. 20.3	502
B 1186	P.A. 122°
Hα: Knot B	
N.W. 0	597
2.7	588
Knot C	
31.5	641
34.4	646
37.3	613
40.2	625
Knot D	
64.1	590
67.0	631
69.9	612
72.8	594
S.E. 75.7	582

Distance From Center (Sec. of Arc)	Velocity (km/sec)
B 1187	P.A. 93°
Hα:	
N.W. -10.4	661
- 7.5	656
- 4.6	658
- 1.7	646
+ 1.2	663
+ 4.1	680
+ 6.9	689
+ 9.8	661
+12.7	647
+15.6	649
+18.5	635
+21.4	652
S.E. +24.3	630

* In all spectra except two through the nucleus (B 805 and B 1187), the zero of distance is taken as the point where Hα was first measurable (in general, this point corresponds to an edge of a region that appears fairly bright - Fig. 1).

TABLE 3

MEAN VELOCITY (WITH RESPECT TO NUCLEUS) OF EMISSION KNOTS

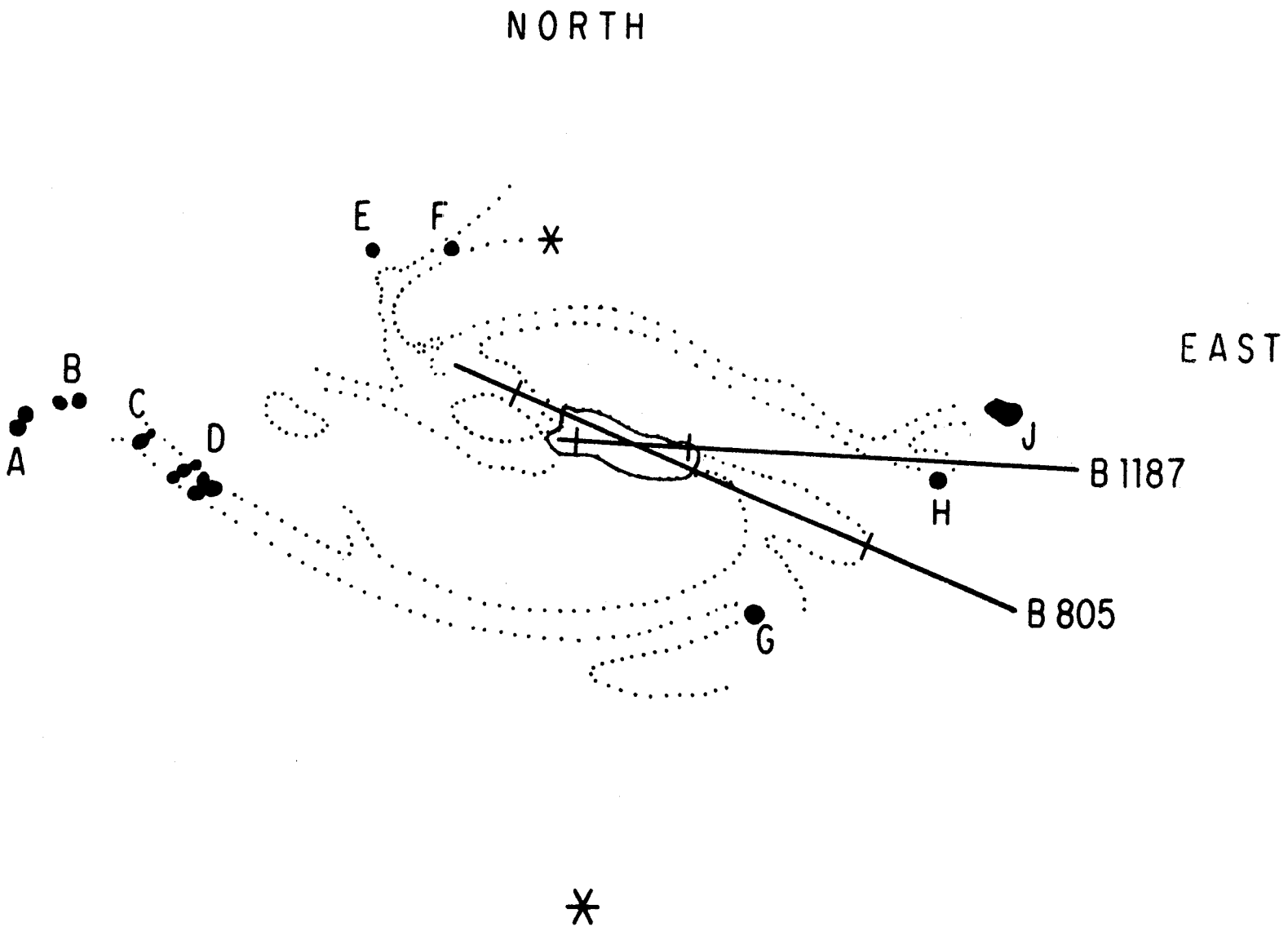
Emission Knot	Velocity (km/sec)	Emission Knot	Velocity (km/sec)
A	+ 41	F	+48
B	+ 12	G	-45
C	+ 51	H	-37
D	+ 22	J	+21
E	+124:		

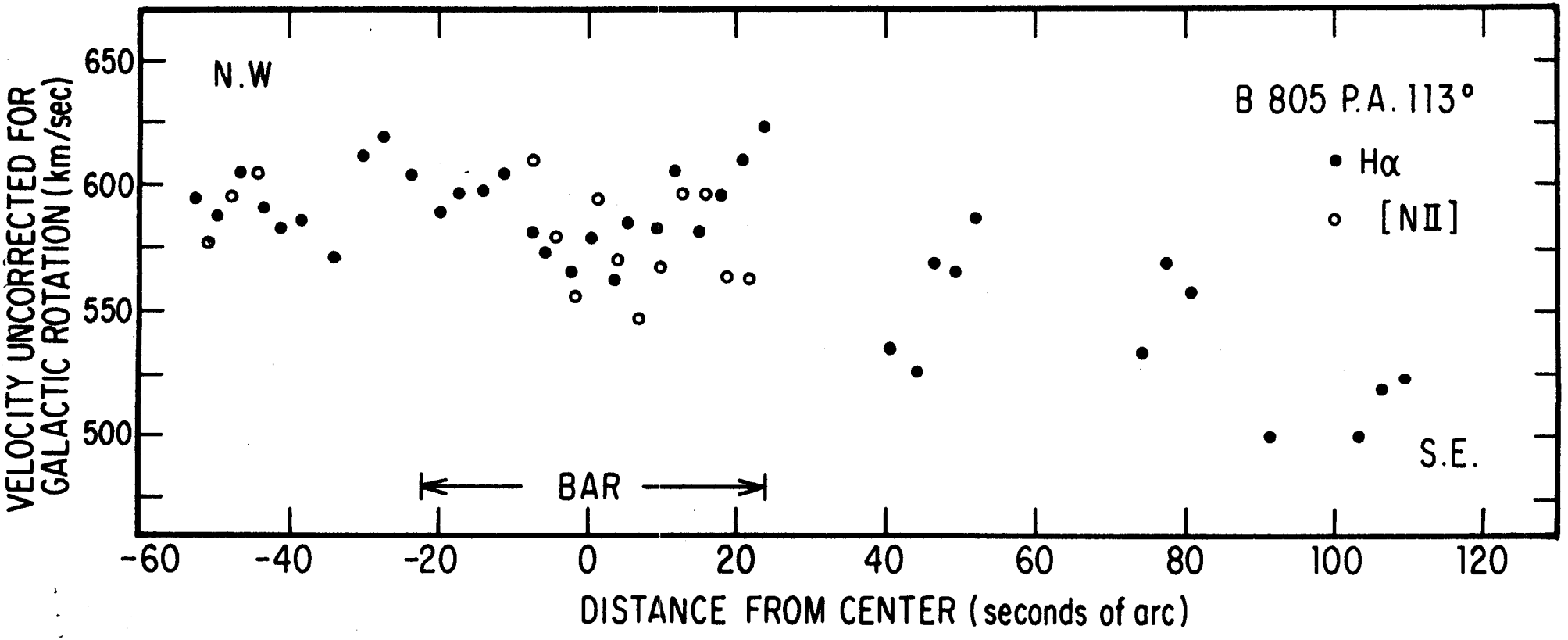
FIGURE CAPTIONS

Fig. 1 - NGC 925, photographed at prime focus of 82-inch telescope on baked Eastman Kodak IIa-O plate through a Schott GG 13 filter. North is at left, east at top. Scale: 1 mm = 0".0.

Fig. 2 - Sketch of NGC 925, showing slit orientations across nucleus. Short bars indicate the limits within which velocities were measured. Letters A through J mark outer emission regions for which velocities have been obtained.

Fig. 3 - Measured velocities, uncorrected for rotation of our Galaxy, plotted against distance from center from spectrum B 805 (P.A. 113°).


NORTH
EAST
E
F
A
B
C
D
J
H
G
B 1187
B 805


N.W
B 805 P.A. 113°
Hα
[NII]
S.E.
BAR
VELOCITY UNCORRECTED FOR GALACTIC ROTATION (km/sec)
650
600
550
500
-60
-40
-20
0
20
40
60
80
100
120
DISTANCE FROM CENTER (seconds of arc)